ECH System Developments Including the Design of an Intelligent Fault Processor

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A new generation fault processor is in development which is intended to reduce the number of incomplete DIII-D shots due to gyrotron faults. The processor, which is based upon a field programmable gate array (FPGA) device, will analyze signals for aberrant operation and ramp down high voltage to try to avoid hard faults. The processor will then attempt to ramp back up to an attainable operating point. One of the most common faults is the loss of rf generation. If not caught quickly enough, this can lead to secondary faults such as high internal pressure, internal arcing, or high body current; all of which require more recovery time than the initial fault. By ramping down immediately in response to the loss of rf generation, it is anticipated that operation can be resumed in time to still contribute in a meaningful way to the DIII-D shot.

An FPGA based fault processor has been in use for three years on one gyrotron system and two years on another. They have proven to be exceptionally reliable in performing the traditional function of a fault processor, terminating pulses in response to detected faults. The processor responds within about 1 μs and can discriminate a first fault when multiple events are separated by more than 40 ns. This version includes watchdog functions, pulse length counting and limiting, duty cycle limiting, and confirming high voltage tracks the reference. Limits are set with digital precision. Communication with the control system allows the fault response to be automatically tailored to the current operating mode.

The new generation fault processor will be developed during an expansion of the electron cyclotron heating (ECH) areas that will include the installation of a depressed collector gyrotron and associated equipment. The design of these items will be very similar to the existing equipment, with most deviations due to upgrades that have been in progress. An extra layer of interlocks will be added to the gyrotron filament controls system, providing a more secure environment for 24 hour operation of the filament. An extra layer of interlocks will also be added for the magnet currents to compensate for a deficiency discovered in the interlocks provided by the magnet power supplies. The new electronics room for the new tanks will be between two high voltage power supplies and the expanded gyrotron hall. Therefore, the electronics cabinets will include extra shielding.

Existing systems will also be upgraded during the current Long Torus Opening II (LTO II) period. Testing of real-time control of the ECH launcher polodial drives by the DIII-D plasma control system (PCS) will be completed. The ECH control system software will be upgraded for increased scalability and to increase operator productivity. Time permitting, all systems will receive the extra layer of interlocks for the filament and magnet power supplies, added shielding for the tank electronics, programmable filament boost shape for long pulses, and electronics upgrades for the installation of the advanced fault processor.

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